

## Claims

- [c1] A method for manufacturing a device including an n-type device and a p-type device, comprising:
  - doping a portion of a semiconductor substrate;
  - forming a gap in the semiconductor substrate by removing at least a portion of the doped portion of the semiconductor substrate; and
  - growing a strain layer in at least a portion of the gap in the semiconductor substrate.
- [c2] The method of claim 1, wherein the strain layer is grown on at least a portion which is substantially directly under a channel of the n-type device.
- [c3] The method of claim 1, wherein the strain layer is grown on at least a portion which is substantially directly under at least one of a source region or drain region of the p-type device.
- [c4] The method of claim 3, wherein the strain layer is not grown under a channel of the p-type device.
- [c5] The method of claim 1, further comprising/depositing a patterned photo-resist layer on a semiconductor substrate, wherein the step of depositing comprises:

depositing a photo-resist layer which covers a portion of the semiconductor substrate which is to be under a channel of the p-type device.

- [c6] The method of claim 5, wherein the photo-resist layer exposes a portion of the semiconductor substrate which is to be under a channel of the n-type device.
- [c7] The method of claim 1, wherein the gap is a tunnel formed under the channel of an n-type device.
- [c8] The method of claim 1, further comprising removing the deposited patterned photo-resist layer.
- [c9] The method of claim 8, further comprising depositing a mask on the semiconductor substrate.
- [c10] The method of claim 9, further comprising patterning the deposited mask such that a portion of the semiconductor substrate is covered and a portion of the semiconductor substrate is exposed.
- [c11] The method of claim 10, wherein the step of forming a gap comprises etching the exposed portion of the semiconductor substrate to selectively expose a side-wall of at least a portion of the doped region of the semiconductor substrate.
- [c12] The method of claim 11, further comprising depositing a

spacer material over the semiconductor substrate.

- [c13] The method of claim 12, wherein the depositing of the spacer material includes depositing the spacer material on exposed portions of the gap.
- [c14] The method of claim 13, further comprising filling unexposed portions of the gap with oxide material.
- [c15] The method of claim 1, wherein the step of doping comprises doping the semiconductor substrate with Ge.
- [c16] The method of claim 15, wherein the doping concentration of the Ge is about  $1 \times 10^{14}$  Ge/cm<sup>2</sup> to about  $1 \times 10^{16}$  Ge/cm<sup>2</sup>.
- [c17] The method of claim 1, wherein the step of doping comprises doping the semiconductor substrate with at least one of As, B, In, and Sb.
- [c18] The method of claim 1, wherein the step of growing a strain layer comprises growing at least one of SiGe, Si<sub>3</sub>N<sub>4</sub>, SiO<sub>2</sub> and SiO<sub>x</sub>N<sub>y</sub> in at least a portion of the gap in the semiconductor substrate.
- [c19] A method for manufacturing a device including an n-type device and a p-type device, comprising:  
growing a strain layer on a semiconductor substrate;  
growing a silicon layer above the strain layer;

forming a gap between the semiconductor substrate and the silicon layer by removing at least a portion of the silicon layer and the strain layer from above the semiconductor substrate; and  
growing a strain layer in the gap.

- [c20] The method of claim 19, wherein the strain layer is grown on at least a portion which is substantially directly under a channel of the n-type device.
- [c21] The method of claim 19, wherein the strain layer is grown on at least a portion which is substantially directly under at least one of a source region or drain region of the p-type device
- [c22] The method of claim 19, wherein the strain layer is not grown under a channel of the p-type device.
- [c23] The method of claim 19, wherein the step of growing a strain layer comprises growing at least one of SiGe,  $\text{Si}_3\text{N}_4$ ,  $\text{SiO}_2$  and  $\text{SiO}_{x,y}$  on the semiconductor substrate.
- [c24] A semiconductor device, comprising:
  - a semiconductor substrate having at least one gap, extending under a portion of the semiconductor substrate;
  - a gate stack on the semiconductor substrate; and
  - a strain layer formed in at least a portion of the gap, wherein the gap is formed by doping a portion of the

semiconductor substrate and then etching the doped portion of the semiconductor substrate.

- [c25] The device of claim 24 wherein the gap is formed prior to forming the gate stack.
- [c26] The device of claim 24, wherein the semiconductor device is doped with at least one of Ge, As, B, In and Sb.
- [c27] A semiconductor device, comprising:
  - a semiconductor substrate having at least one gap, extending under a portion of the semiconductor substrate;
  - a gate stack on the semiconductor substrate; and
  - a strain layer formed in at least a portion of the one gap, wherein the strain layer is formed only under at least one of a source region and a drain region of the semiconductor device.
- [c28] The device of claim 27, wherein the semiconductor device is a p-type device.
- [c29] The device of claim 27, wherein the strain layer is made of at least one of silicon germanium or silicon carbide.
- [c30] The device of claim 27, wherein the strain layer is between a surface of an upper portion of the semiconductor substrate which faces a surface of a lower portion of the semiconductor substrate.

- [c31] The device of claim 27, wherein the strain layer has a thickness of about 1000 Angstroms to about 5000 Angstroms.
- [c32] The device of claim 31, wherein a thickness of the channel is about 30 Angstroms to about 200 Angstroms.
- [c33] The device of claim 27, wherein the strain layer is formed under both the source region and the drain region of the semiconductor device
- [c34] The device of claim 27, wherein the gap has a first width along an upper surface of the semiconductor substrate and a second width below the upper surface of the semiconductor substrate and the second width is larger than the first width.
- [c35] The device of claim 27, wherein compressive stresses of about 100 MPa to about 3 GPa exist within the channel of the device.
- [c36] The device of claim 27, wherein the strain layer is at least one of SiGe,  $\text{Si}_3\text{N}_4$ ,  $\text{SiO}_2$  and  $\text{SiO}_x\text{N}_y$ .